

R. Decker

Operating Instructions

for

PROPERTY OF ENGINEERING
TEST EQUIPMENT
GROSLEY, DIV. OF AVCO

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FM AND AM SIGNAL GENERATOR TYPE TF 1066/1



Marconi Instruments Limited

ST. ALBANS • HERTFORDSHIRE • ENGLAND

GROUND COMMUNICATIONS SECTION



PROPERTY OF ENGINEERING
TEST EQUIPMENT
CROSLEY, DIV. OF AVCO

ITEM.....COPY.....

OPERATING INSTRUCTIONS
FOR
FM AND AM SIGNAL GENERATOR
TYPE TF 1066/1

Amendments: The following
Amendment Sheets are included
at the commencement of the
Appendices section:

AM1

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COMPLETE CIRCUIT DIAGRAM.....	TC 24602/1 (2 sheets)

SCHEDULE OF PARTS SUPPLIED

The complete equipment comprises the following items:-

1. One FM and AM Signal Generator Type TF 1066/1 complete with attached mains lead and valves etc. as under:-

Valves: One: Type 5Z4G, Full-Wave Rectifier.
 One: Type 6AK6, Pentode.
 One: Type 5861, (DET22), Disc-Seal Triode.
 One: Type 6AK5, (EF 95), Pentode.
 One: Type 6C4, (L77), Triode.
 One: Type 12AX7, Double Triode.
 One: Type 6L6G, (KT66), Tetrode.
 One: Type 6CD6G, Tetrode.
 One: Type OB2, (QS1208), Voltage Stabilizer.
 One: Type 85A2, Voltage Stabilizer.
 Two: XBl, Barretters.

Lamp: One: 6.3-volt, 0.15-amp, M.B.C. Pilot Lamp.

Crystals: One: Type CS2A, Silicon Crystal Diode.
 Two: Type CG1E, Germanium Crystal Diodes.

Fuses: One: 0.25-amp, Cartridge.
 Two: 2.0-amp, Cartridge.

2. One Output Lead, 50-ohm, Type TM 4824.
3. One CORRECTION CHART FOR DEVIATION AND INCREMENTAL FREQUENCY MONITOR -- card to TC 25688, normally stowed in left-hand case-handle recess.
4. One Instruction Book No. EB 1066/1.

Also, the following output accessories are available for use with the instrument.

5. 20-dB Pad, 50-ohm, Type TM 4919.
6. 6-dB Pad, 50-ohms, Type TM 4919/1.
7. Matching Unit, 50 ohms to 75 ohms, Type TM 4918.
8. Matching Unit, 50 ohms Unbalanced to 300 ohms Balanced, Type TM 4916.
9. D.C. Isolating Unit Type TM 4917.

1.

DESCRIPTION

1.1. GENERAL

The Marconi TF 1066/1 Signal Generator covers the carrier frequency range 10 to 470 Mc/s. The primary purpose of the instrument is to provide frequency modulated outputs but amplitude modulated outputs can also be obtained. The open-circuit output voltage is continuously variable from 0.2 μ V to 200 mV; the output impedance is 50 ohms.

Tuning and Incremental Frequency Controls. The frequency range is covered in five bands, each having its own directly-calibrated scale on the main dial. There are two tuning controls: one, the normal or coarse control linked to the frequency dial, and the other, an uncalibrated FINE TUNING control with a total cover of the order of 25 kc/s. For bandwidth measurements etc., there is a continuously-variable INCRemental FREQUENCY control, with which small known changes in the carrier frequency can be made, the magnitude of these changes being indicated directly on the appropriate scales of the MODULATION AND INCREMENTAL FREQUENCY meter. This meter has two incremental frequency scales selected by means of a switch; one scale is calibrated at 10-kc/s intervals from -100 kc/s to +100 kc/s, and the other is calibrated at 2-kc/s intervals from -20 kc/s to +20 kc/s.

As well as the continuously-variable INCRemental FREQUENCY control, there is an INCRemental FREQUENCY switch. With this switch in use, the meter and continuously-variable control are inoperative and carrier frequency shifts up to ± 15 kc/s can be made in 5-kc/s steps.

Frequency Modulation can be applied at any deviation up to 100 kc/s. A built-in a.f. oscillator provides the internal modulating signal, the frequency of this oscillator being 1 kc/s or 5 kc/s depending on the setting of a toggle-type selector switch. External modulation can be applied at any frequency between 30 c/s and 15 kc/s. For both internal and external modulation, the deviation is indicated directly in kilocycles per second on the modulation scales of the MODULATION AND INCREMENTAL FREQUENCY meter.

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1.1. (Continued)

Amplitude Modulation can be applied at any depth up to 40% from the same sources - both internal and external - as for f.m. The modulation depth is monitored by direct measurement of the a.f. signal obtained from demodulation of the r.f. output of the master oscillator. It is indicated on the MODULATION AND INCREMENTAL FREQUENCY meter, the same scales being used for a.m. depth as for f.m. deviation. These scales are calibrated 0 - 20 and 0 - 100 respectively, the sensitivity being selected by means of a switch.

The R.F. Output Level of the Signal Generator is adjusted by means of a 50-ohm piston attenuator and indicated on a $4\frac{1}{2}$ -inch dial. This dial has two scales - one calibrated directly in units of voltage and the other in decibels relative to 1 μ V. The cursor fitted to the attenuator dial is reversible; with one face of this cursor exposed, the hairlines indicate source e.m.f.; when the cursor is turned over, the indication is in terms of the p.d. developed across a 50-ohm load.

1.2. DESIGN DETAILS

The general arrangement of the electrical circuits is shown on the Functional Diagram, Drawing No. TBB 24743, and the complete Circuit Diagram is given on Drawing No. TC 24602/1. Reference to these diagrams should assist the reader in fully understanding the principles described in this section.

The R.F. Unit. Generating at the output frequency without the use of harmonic multipliers, the r.f. oscillator employs a disc-seal triode (V6) in a shunt-fed derived Colpitts circuit. The twin-section Colpitts capacitor consists of two separate sets of stator vanes and a common rotor. The two sets of stator vanes are linked by a tuning inductor and there are separate stator-vane/tuning-inductor assemblies for each of the five frequency bands. These five assemblies are mounted in a rotatable turret which is designed so that the stator vanes of only one assembly mesh actively with the vanes of the central rotor. Operation of the range-change switch turns the turret so that a different stator-vane/tuning-inductor assembly is brought into electrical association with the rotor. This system of contactless waveband selection is a Marconi patent and it avoids the necessity for passing heavy r.f. circulating currents through metal-to-metal contacts with their inevitably varying contact resistances.

1.2. (Continued)

Tuning over any one band is accomplished by movement of the Colpitts-capacitor rotor. This is coupled to the main tuning control on the front panel via a precision slow-motion drive system which comprises a 55:1 gear train with anti-backlash spring loading.

The level of output from the r.f. oscillator is monitored by a crystal-diode voltmeter (MR2 and M1) inductively coupled to the oscillatory circuit. When the Signal Generator is in use, the output of the oscillator is set up to a reference level, as indicated by a calibration mark on the meter scale, by means of the SET CARRIER control (RV6) which varies the oscillator h.t. voltage.

The piston attenuator is coupled to its indicator dial by a rack-and-pinion drive mechanism, which, like the main tuning drive, is spring loaded to reduce backlash; the panel control operates through a friction-type slow-motion drive to the attenuator-dial spindle. The pick-up element is of the mutual inductance type and is fitted with a resistance-capacitance network to maintain the output impedance constant at 50 ohms. The output connector and accessories are listed in the Schedule of Parts Supplied, page 3.

Modulation. The internal modulation signal is derived from a conventional Hartley oscillator utilizing a single triode valve (V7) and a tuned transformer (T2); the modulation-frequency-selector switch (SE) brings into circuit the appropriate tuning capacitor to give either 1 kc/s or 5 kc/s as required. The output level of this oscillator is varied by means of the SET MOD control (RV5), which is connected across the secondary winding of T2. The signal is fed to the amplitude- or frequency-modulating circuits via the modulation-selector switch (SC). This switch also disconnects the h.t. of the modulating oscillator when set for c.w. or external modulation.

Frequency modulation is effected by the use of a magnetic reactor (TR1) which forms part of the r.f. oscillator tuned circuit. The modulating signal is fed via a resistive correcting network to the grid of an amplifier valve (V2) driving the reactor. This correcting network is varied by both the main tuning control and the frequency range switch. It is included in the circuit since, for any one value of deviation, the level of a.f. drive required

1.2. (Continued)

by the reactor is not constant but is a function of carrier frequency; this is because the reactance variation which must be produced by the reactor changes with changes in the main reactance values in the oscillator tuned circuit.

The carrier is amplitude modulated by direct anode modulation of the r.f. oscillator valve, the modulating signal being applied, via an amplifier valve (V8), the SET CARRIER control (RV6), and an r.f. filter to the anode of V6.

Fine Tuning and Incremental Tuning Controls. The FINE TUNING control (RV9) varies the r.f. oscillator frequency by varying the h.t. voltages of the reactor-driver valve and, hence, the standing current in the magnetic reactor. The continuously-variable INCRemental FREQUENCY control (RV1) acts on the reactor in a similar manner to the FINE TUNING control but produces its effect by varying the level of a d.c. voltage applied to the correcting network in the grid circuit of the reactor driver. This d.c. voltage is monitored directly by the MODULATION AND INCREMENTAL FREQUENCY meter (M2) when the monitor-selector switch (SD) is set to one of its INC FREQ positions - the meter scale has, of course, a frequency shift calibration in terms of kc/s. By operation of the INCRemental FREQUENCY switch (SF), the continuously-variable control may be taken out of circuit and a voltage derived from a stepped potentiometer system applied to the correcting network to produce frequency shifts of 5, 10, or 15 kc/s in either direction.

Modulation Monitor. The MODULATION AND INCREMENTAL FREQUENCY meter is used for monitoring both f.m. and a.m. and also the incremental frequency shift. The operation of the monitoring system can most easily be understood by considering the amplitude-modulation monitor first.

For monitoring of a.m. depth, the a.f. component of the voltage output from the r.f. monitor detector (MR2) is fed, via a blocking capacitor, to the grid of an amplifier comprising the first triode section of a double-triode valve (V9) with its associated components. The output of this amplifier is fed to the grid of the second triode section, which is connected as a cathode follower. The final output from this cathode follower is rectified by crystal diodes (MR3 and MR4) and passed to the monitoring meter, M2.

1.2. (Continued)

When the Signal Generator is set for frequency modulation, the grid of the cathode-follower section of V9 is disconnected from the amplifier by the action of the modulation-selector switch; it is coupled to the input of the correcting network of the reactor driver so that the level of the audio signal applied to the network is monitored. Since the correcting network is automatically adjusted to keep the ratio of a.f. input voltage to f.m. deviation constant at all carrier frequencies, the meter gives a correct reading of f.m. deviation.

Power Supply. The mains transformer which forms part of the built-in power unit has a double-wound primary, the two tapped sections of which can be connected in series or series-parallel to allow operation from a selection of supply voltages in the ranges 180 to 250 volts and 100 to 150 volts; full details of the method of adjusting the power unit to suit different supply voltages, and also either 40- to 60-c/s or 500-c/s supply frequencies, are given in Sections 3.3. to 3.3.4. inclusive.

The main h.t. supply is derived from a low-impedance series-stabilizer circuit (comprising valves V3 and V4 with the reference potential controlled by the gas-filled stabilizer V5); the input for this circuit is drawn from the centre-tapped h.t. winding on the transformer via a full-wave rectifier (V1). A negative reference voltage for the INCremental FREQUENCY controls is drawn from the h.t. winding via a voltage-doubler circuit utilizing a metal rectifier (MR1), the voltage being controlled by the gas-filled stabilizer V10.

The heater supply to the r.f. oscillator and reactor-driver valves (V6 and V2) is stabilized by a pair of barretters (V11 and V12).

2.

OPERATION

2.1. INSTALLATION

Signal Generator TF 1066/1 can be adjusted to allow operation from any 40-c/s to 60-c/s power supply, or any 500-c/s power supply, in the voltage ranges 100 to 150 volts and 180 to 250 volts.

Full instructions for adjusting the internal power unit to suit the local supply are given in Sections 3.3. to 3.3.4.

Unless otherwise specified, the Signal Generator is normally despatched ready for immediate operation from 230-volt, 40- to 60-c/s supplies.

2.2. SWITCHING ON AND WARMING UP

Be sure that the instrument is correctly adjusted to suit the particular mains supply to which it is to be connected. Then proceed as follows:-

- (1) Connect the mains lead - which is stowed, when not in use, in the left-hand case-handle recess - to the mains supply socket.
- (2) Switch ON by means of the SUPPLY switch. The red pilot lamp should then glow.
- (3) Before proceeding further, wait two or three minutes for the valves to warm up. If a very high order of stability is required, this period should be extended to approximately half an hour.

2.3. TUNING

The Signal Generator covers its frequency range in five bands:-

10 to 22 Mc/s
22 to 48 Mc/s
48 to 110 Mc/s
110 to 240 Mc/s
240 to 470 Mc/s

2.3. (Continued)

To tune the Signal Generator to a particular frequency proceed as follows:-

- (1) Set the INC FREQ switch to its central 'zero' position, and the FINE TUNING control to mid travel.
- (2) Select the required band by means of the RANGE switch. To change from one band to another, rotate the control through one-and-a-fifth turns per band until it locates positively with the knob pointing to the desired band.
- (3) By means of the main frequency control, tune the Signal Generator to the required carrier frequency as indicated on the main tuning dial. Using the hairline on the transparent cursor, read the frequency on the calibration arc appropriate to the band selected in (2) above.

When very precise tuning is required - e.g., when peaking the tuning to the centre frequency of a receiver - the final adjustment should be made with the uncalibrated FINE TUNING control; the total cover of this control is of the order of 25 kc/s.

For measurements which necessitate small accurately-known changes in carrier frequency, such as frequency response determinations, the INCRemental FREQuency controls should be used. The tuning procedure when using these controls is described in the following instructions.

2.3.1. Using The Continuously-Variable Incremental Frequency Control

- (1) Set the INC FREQ switch to VAR and the monitor-selector switch to INC FREQ 20 kc/s; then adjust the continuously-variable INC FREQ control to bring the pointer of the MODULATION AND INCREMENTAL FREQUENCY meter to the centre-zero mark on the lowest scale on the dial.
- (2) Use the main frequency control to tune the Signal Generator to the approximate centre frequency of the equipment under test, and set up for c.w. or a.m. as described in Sections 2.4.1. and 2.4.3. - response or bandwidth measurements are not normally made with a frequency modulated signal.

2.3.1. (Continued)

- (3) If, in (2) above, the monitor-selector switch has been turned to a MOD position, restore it to one of its INC FREQ positions - either 20 or 100 kc/s depending on the range over which incremental frequency variations are to be made.
- (4) Tune the Signal Generator accurately to the centre frequency of the equipment under test using the main and FINE TUNING controls.

With the TF 1066/1 tuned to the centre frequency in the manner described above, the variable INC FREQ control affords a simple and convenient means of varying the carrier frequency by a small amount in either direction. The frequency change introduced by movement of the variable INC FREQ control is indicated directly at all carrier frequencies on the MODULATION AND INCREMENTAL FREQUENCY meter; the incremental scales are easily identified, being marked in red on the lowest arc of the meter dial.

At carrier frequencies below 110 Mc/s, the meter indication is accurate to within 5% of full-scale deflection - i.e., within 1 kc/s on the -20 to +20 range and within 5 kc/s on the -100 to +100 range. Between 110 and 240 Mc/s, the indication is generally accurate to within 5% of f.s.d. but may fall outside this tolerance at certain frequencies in the band. A curve giving a correction for frequency shift against carrier frequency over the range 110 to 240 Mc/s is shown in red on the CORRECTION CHART FOR DEVIATION AND INCREMENTAL FREQUENCY MONITOR - this chart is in the form of a card and is normally stowed in the left-hand case-handle recess. Above 240 Mc/s the accuracy falls off to 20% of f.s.d., but an accuracy of 5% of f.s.d. can be obtained by applying the correction given by the black curve on the chart.

2.3.2. Using The Stopped Incremental Frequency Switch.

- (1) Set the INC FREQ switch to its zero position.
- (2) Use the main frequency control to tune the Signal Generator to the approximate centre frequency of the equipment under test and set up for c.w. or a.m. as described in Sections 2.4.1. and 2.4.3.
- (3) Tune the Signal Generator accurately to the centre frequency of the equipment under test using the main and FINE TUNING controls.

2.3.2. (Continued)

With the TF 1066/1 tuned to the centre frequency in the manner just described, the INC FREQ switch can be used to change carrier frequency in steps of 5 kc/s. The frequency changes can be made in either direction up to a maximum of 15 kc/s and the system is particularly useful when making bandwidth checks on, say, a number of similar receivers in production testing, or at various carrier frequencies on one particular receiver.

It should be noted that the Incremental Frequency monitor is inoperative when frequency changes are being made by means of the INC FREQ switch, i.e., when the switch is set to any position other than VARIABLE.

Up to a carrier frequency of 110 Mc/s, frequency changes made with the INC FREQ switch are accurate to within 7% of the value indicated by the switch setting. From 110 to 240 Mc/s, the accuracy is generally within 7% but may fall outside this tolerance at certain frequencies in the band. Above 240 Mc/s, the accuracy falls to 20%. The CORRECTION CHART supplied with the Signal Generator is primarily for use with the Deviation and Incremental Frequency Monitor. Although the Incremental Frequency monitor is not in use when making frequency changes with the INC FREQ switch, the chart can, nevertheless, be utilized. By means of the chart, the actual frequency change introduced at the various settings of the INC FREQ switch can be determined to within 7% at all carrier frequencies. The following example illustrates the use of the CORRECTION CHART for this purpose.

Example: The chart supplied with a representative TF 1066/1 showed that, at 340 Mc/s, a correction of approximately -10% should be applied to deviation and incremental frequency readings on the monitor meter. Applying this figure of -10% to the 5, 10, and 15 kc/s positions on the INC FREQ switch showed that, at 340 Mc/s, the frequency changes introduced were 4.5, 9, and 13.5 kc/s respectively.

2.3.3. Reactor Hysteresis.

When making frequency changes with either of the two INC FREQ controls, the operator may find some inconsistency of results due to hysteresis of the magnetic reactor. Errors from this cause will generally be small - of the order of 5% of the shift - and can be virtually eliminated by adopting the following procedure:-

2.3.3. (Continued)

Set the incremental shift to zero; apply f.m. to the carrier at maximum deviation and then progressively reduce it to zero; finally, retune the Signal Generator to the centre frequency of the equipment under test by means of the main - and, if necessary, the fine - frequency control.

2.4. SETTING UP FOR CONTINUOUS WAVE OR MODULATED OUTPUT

The following types of r.f. output can be obtained from the Signal Generator:-

- (i) Continuous Wave - see Section 2.4.1.
- (ii) Frequency Modulated - see Section 2.4.2.
 - (a) from the internal a.f. oscillator.
 - (b) from an external source.
- (iii) Amplitude Modulated - see Section 2.4.3.
 - (a) from the internal oscillator.
 - (b) from an external source.

2.4.1. Continuous Wave

- (1) Set the modulation-selector switch to C.W.
- (2) Tune to the desired frequency in the manner described earlier in Section 2.3.
- (3) Turn the ATTENUATOR control to bring the dial to the required setting. (A detailed explanation of the method of setting the r.f. output voltage is given in Section 2.5. R.F. OUTPUT ARRANGEMENTS.)
- (4) Adjust the SET CARRIER control to bring the pointer of the CARRIER LEVEL meter to the SET CARRIER mark.

2.4.2. Frequency Modulation

The accuracy of the deviation indication and the waveform of the demodulated signal may tend to deteriorate slightly when carrier shift is applied by means of the INC FREQ controls. It is advisable, therefore, to keep the INC FREQ switch in its zero position when using frequency modulation.

2.4.2. (Continued)

(a) Internal F.M.

- (1) Set the modulation-selector switch to INT F.M.
- (2) Tune the Signal Generator, and adjust the ATTENUATOR and SET CARRIER controls to produce the required output in a manner similar to that described for c.w. operation.
- (3) Set the monitor-selector switch to MOD 0-20 or MOD 0-100 depending on the deviation to be used.
- (4) Set the MOD FREQ toggle switch to 1 kc/s or 5 kc/s according to the modulation frequency required.
- (5) Adjust the SET MOD control to bring the pointer of the MODULATION AND INCREMENTAL FREQUENCY meter to the required deviation indication.

At carrier frequencies below 110 Mc/s, the deviation indication is accurate to within 5% of full-scale deflection. Between 110 Mc/s and 240 Mc/s, the indication is generally accurate to within 5% of f.s.d. but may fall outside this tolerance at certain frequencies in the band. A curve giving the correction for deviation against carrier frequency over the range 110 to 240 Mc/s is shown in red on the CORRECTION CHART FOR DEVIATION AND INCREMENTAL FREQUENCY MONITOR; this chart is in the form of a card and is normally stowed in the left-hand case-handle recess. Above 240 Mc/s, the deviation accuracy falls to 20% of f.s.d. but an accuracy of 5% of f.s.d. can be obtained by applying the correction given by the black curve on the chart.

When the modulation selector is set to INT F.M., the internal modulating signal is available at the EXT MOD F.M. and earth terminals and provides a convenient synchronizing signal when the Signal Generator is used in conjunction with a cathode-ray oscilloscope. At the maximum deviation of 100 kc/s, the level of this signal is of the order of 20 volts r.m.s.

NOTE: If the circuit of any apparatus connected to the EXT MOD F.M. and earth terminals offers a path to d.c., then a capacitor should be inserted in the lead used to make connection to the EXT MOD F.M. terminal. If this capacitor is omitted, the potentiometer network controlled by the INC FREQ switch will be shunted and the accuracy of the incremental frequency steps will be affected.

2.4.2. (Continued)

(b) External F.M.

- (1) Set the modulation-selector switch to EXT F.M.
- (2) Connect the external a.f. signal source to the EXT MOD F.M. and earth terminals - see NOTE at end of Sect 2.4.2. (a).
- (3) Tune the Signal Generator and adjust the ATTENUATOR and SET CARRIER controls to produce the required output in a manner similar to that for c.w. operation.
- (4) Set the monitor-selector switch to MOD 0-20 or MOD 0-100 depending on the deviation to be used.
- (5) Adjust the level of input from the external source to bring the pointer of the MODULATION AND INCREMENTAL FREQUENCY meter to the required deviation mark on the scale appropriate to the setting of the monitor-selector switch; apply the necessary correction to the meter reading for carrier frequencies above 110 Mc/s.

The impedance presented at the EXT F.M. and earth terminals to the external modulating source is nominally 5 k Ω . An input of the order of 20 volts is required to produce the maximum deviation of 100 kc/s. Between 30 c/s and 15 kc/s, the amplitude-frequency characteristic of the modulating circuit is flat to within 1 dB relative to the response at 1 kc/s.

2.4.3. Amplitude Modulation(a) Internal A.M.

- (1) Set the modulation-selector switch to INT A.M. and turn the SET MOD control fully counter-clockwise.
- (2) Tune the Signal Generator and adjust the ATTENUATOR and SET CARRIER controls to produce the required output level in a manner similar to that described for c.w. operation.
- (3) Set the monitor-selector switch to MOD 0-20 or MOD 0-100 depending on the depth of modulation to be applied.

2.4.3. (Continued)

- (4) Set the MOD FREQ toggle switch to 1 kc/s or 5 kc/s according to the modulation frequency required.
- (5) Advance the SET MOD control until the pointer of the MODULATION AND INCREMENTAL FREQUENCY meter indicates the required modulation-depth on the scale appropriate to the setting of the monitor-selector switch. The movement of the SET MOD control may cause a change in the deflection of the CARRIER LEVEL meter pointer; do not re-adjust the SET CARRIER control to bring the pointer back to the SET CARRIER mark.

On the 0-20 range of the modulation monitor, the mod. depth indication is accurate to within 2% modulation. On the 0-100 range, the indication is accurate to within 5% modulation up to 40%. Although the specified maximum mod. depth for the TF 1066/1 is 40%, mod. depths considerably greater than this can generally be obtained. Nevertheless, the specified maximum mod. depth should be borne in mind, and the modulation depth indication should not be regarded as valid over 40%.

When the modulation-selector switch is in the INT A.M. position, the 1-kc/s or 5-kc/s input to the modulation amplifier is also applied to the EXT MOD A.M. and earth terminals, and provides a convenient synchronizing signal when the Signal Generator is used in conjunction with a cathode-ray oscilloscope. At 40% modulation depth, the level of this signal is of the order of 10 volts r.m.s.

(b) External A.M.

- (1) Set the modulation-selector switch to EXT A.M.
- (2) Tune the Signal Generator and adjust the ATTENUATOR and SET CARRIER controls to produce the required output in a manner similar to that described for c.w. operation.
- (3) Set the monitor-selector switch to MOD 0-20 or MOD 0-100 depending on the modulation depth to be applied.

2.4.3. (Continued)

- (4) Connect the external a.f. source to the EXT MOD A.M. and earth terminals, and adjust the input level until the pointer of the MODULATION AND INCREMENTAL FREQUENCY meter indicates the required modulation-depth on the scale appropriate to the setting of the monitor-selector switch. If this action causes a change in the deflection of the CARRIER LEVEL meter, do not readjust the SET CARRIER control to bring the pointer of the meter back to the SET CARRIER mark.

The impedance presented at the EXT A.M. and earth terminals to the external modulating source is nominally 1 M Ω shunted by 20 pF. An input of the order of 10 volts is required to produce 40% modulation depth. Between 30 c/s and 15 kc/s the amplitude-frequency characteristic of the modulating circuit is flat to within 1 dB relative to the response at 1 kc/s.

2.5. R.F. OUTPUT ARRANGEMENTS

For consideration of its output circuit, the TF 1066/1 can be regarded as a zero-impedance voltage generator in series with a resistance of 50 ohms. This condition is shown diagrammatically in figure 1 of drawing No. TBB 25403, where E is the source e.m.f., R_0 is the source impedance of the Signal Generator, Z_L is the load impedance, and V_L is the voltage actually developed across the load.

The Attenuator Dial. This dial has two scales: one is calibrated from -14 to +120 and indicates the output in decibels relative to 1 μ V; the other is calibrated directly in units of voltage.

With the SET CARRIER control adjusted to bring the CARRIER LEVEL meter pointer to the SET CARRIER mark, the attenuator scales are direct reading, each in its particular units as described in the previous paragraph.

The Reversible Cursor. The transparent cursor fitted to the attenuator dial is reversible and is engraved with two hairlines, one vertical and one inclined at an angle corresponding to a 6-dB movement of the dial.

2.5. (Continued)

On one side of the cursor, the inclined hairline is marked E.M.F. FROM 50 OHM SOURCE and the vertical hairline is marked -6 dB. When the cursor is fitted with this side showing, the inclined hairline indicates the output level in terms of source e.m.f. (E in figure 1 of TBB 25403). The dial reading at the vertical hairline is the effective source e.m.f. when the 6-dB Attenuator Pad Type TM 4919/1 is in use. (See Section 2.5.1.).

On the other side of the cursor, the vertical hairline is marked VOLTS INTO 50 OHM LOAD and the inclined hairline is marked -6 dB. When the cursor is fitted with this side showing, the output level indicated by the vertical hairline is in terms of the potential (V_L in figure 1 of TBB 25403) developed across a 50-ohm load connected to the r.f. outlet of the Signal Generator. The dial indication at the inclined hairline is the voltage appearing across a 50-ohm load when the 6-dB Pad is in circuit.

To reverse the cursor:-

- (1) First, extract the centre screw securing the transparent plastic window of the attenuator dial.
- (2) Remove the window and take off the spun-metal cover and spacer at the centre of the dial.
- (3) Lift out the cursor, turn it over, and replace it.
- (4) Finally, replace the spacer and the spun cover and the transparent window, and secure them in position with the centre screw.

2.5.1. Coupling To The Equipment Under Test (Use of Output Accessories)

Because the Signal Generator has an output impedance which is nominally equal to the characteristic impedance of the CONNECTOR cable, this cable may be regarded as correctly terminated at the input end, so that the possibility of standing waves causing serious errors in the apparent e.m.f. can generally be neglected even when the input impedance of the equipment under test is not equal to 50 ohms.

However, it is often important for other reasons that the source impedance is accurately matched to the load or that it has a particular known value not equal to 50 ohms. Under those circumstances, the source impedance at the output end of the

2.5.1. (Continued)

system can be altered to the required value by the use of various matching networks; a selection of these and other accessories are supplied for use with the instrument.

The following paragraphs deal with the characteristics and uses of these accessories; general details are also given to assist the user if his own particular requirements are not met by the accessories supplied.

The Output CONNECTOR Type TM 4824. This is a 50-ohm coaxial cable 36 inches long and fitted at either end with a standard type N free plug (United States, Military No. UG-21B/U; Great Britain, Transradio Ltd. type GE.071). These plugs mate with either a standard type N free socket (United States, Military No. UG-23B/U; Great Britain, Transradio Ltd. type 6.043) or a panel mounting type N socket (United States Military No. UG-22B/U; Great Britain, Transradio Ltd. type DE.071).

The 20-dB Attenuator PAD Type TM 4919. When the equipment under test has an input impedance other than 50 ohms and it is important that the signal is derived from a 50 ohm source, it is advisable if the insertion loss can be tolerated, to couple the CONNECTOR to the load via the 50-ohm 20-dB attenuator PAD.

With the PAD in circuit, the possibility of error in apparent e.m.f. or effective output impedance due to standing waves is avoided because it is impossible to mis-match the cable seriously - variations in the load impedance from zero to infinity cause the effective line-terminating resistance to depart from its correct value by only 1 ohm approximately.

Figure 2 on Drawing No. TBB 25403 shows diagrammatically the effect of connecting the PAD into circuit. The final output conditions are equivalent to those of a zero-impedance generator producing an e.m.f. equal to $E/10$ in series with a resistance, R_{EO} , of 50 ohms. The p.d. across the load can, of course, be calculated in the usual way and is equal to

$$\frac{E}{10} \times \frac{Z_L}{R_{EO} + Z_L}$$

where E is the e.m.f. indicated on the ATTENUATOR dial.

2.5.1. (Continued)

R_{EO} is the effective source resistance of the Signal Generator (50 ohms)

Z_L is the input impedance of the equipment under test.

The PAD is fitted with a type N socket at its input end and a type N plug at its output end.

The 6-dB Attenuator PAD Type TM 4919/1. This accessory can be used to terminate the CONNECTOR when the load impedance is not equal to 50 ohms and the insertion loss of the 20-dB pad cannot be tolerated.

The effective e.m.f. when the PAD is in circuit is indicated directly by the vortical hairline on the attenuator cursor; i.e., the line marked -6 dB on the side of the cursor bearing the marking E.M.F. FROM 50 OHM SOURCE.

When the cursor is in the position in which the marking VOLTS INTO 50 OHM LOAD is exposed, the p.d. across a 50-ohm load connected to the outlet of the 6-dB PAD is given directly by the inclined hairline marked -6 dB.

The input and output couplings on the 6-dB PAD are the same as those on the 20-dB PAD.

Matching To Loads Less Than 50 ohms. If the Signal Generator is required to have an output impedance of less than 50 ohms, the arrangement shown in Figure 3 can be used. A resistor having a value R_p is connected effectively in parallel with the source resistance of the generator so that the output resistance of the system, R_{EO} , is given by the standard expression for resistances in parallel; viz:

$$R_{EO} = \frac{R_p \times R_0}{R_p + R_0} \dots \dots \dots (1)$$

where R_0 is the output resistance of the Signal Generator.

Since the required output resistance is usually the known term, the above expression is more useful when rearranged as follows:-

2.5.1. (Continued)

$$R_p = \frac{R_o \times R_{EO}}{R_o - R_{EO}} \dots \dots \dots (2)$$

Under those conditions, the effective source o.m.f., E_{EFFECT} , presented to the load is given by the expression

$$E_{EFFECT} = E \times \frac{R_p}{R_p + R_o} \dots \dots \dots (3)$$

where E is the o.m.f. indicated on the ATTENUATOR dial.

When the effective output resistance is altered by the above method, the CONNECTOR is mismatched at its output end; it is therefore advisable, if the insertion loss can be tolerated, to insert the 20-dB PAD between the output end of the CONNECTOR and the correcting resistor, R_p . The effective source o.m.f. is, of course, then reduced by a factor of 20 dB.

Matching To Loads Greater Than 50 ohms. If the required output impedance is greater than 50 ohms, a resistor having a value R_s can be connected in series with the output as shown in Figure 4 on TBB 25403. With this arrangement, the effective output resistance, R_{EO} , is given by the expression for resistances in series, viz:

$$R_{EO} = R_o + R_s \dots \dots \dots (4)$$

or, more conveniently

$$R_s = R_{EO} - R_o$$

where R_o is the output resistance of the Signal Generator.

For the special case where R_{EO} is equal to 75 ohms, the 50-ohm to 75-ohm MATCHING UNIT, Type TM 4918 is available. This unit contains a 25-ohm resistor which, connected in series with the 50-ohm source resistance of the Signal Generator, gives an effective output resistance of 75 ohms. The MATCHING UNIT is fitted with a type N socket at its input end and a Belling Lee Ltd. type L734/P plug at its output end; this plug mates with a Belling Lee Ltd. free socket type L734/J or panel mounting socket type L604/S.

2.5.1. (Continued)

When the effective output resistance is altered by the above method, the CONNECTOR is mismatched at its output end; it is therefore advisable, if the insertion loss can be tolerated, to insert the 20-dB PAD between the output end of the CONNECTOR and the correcting resistor, R_S . The effective source e.m.f. is, of course, then reduced by a factor of 20 dB.

Using the Signal Generator with Balanced Loads. With certain types of equipment, the input circuit is in the form of a balanced winding. Such equipment can be fed from the unbalanced output of the Signal Generator via two correcting resistors as shown in Figure 5 on Diagram No. TBB 25403; this arrangement makes use of the auto-transformer effect of the centre-tapped winding to simulate the behaviour of a balanced source. One resistor, R_{S1} , is connected in series between the earthed screen of the output accessory in use and one side of the balanced winding, and a second resistor, R_{S2} , is connected in series with the 'live' output connection and the other side of the balanced winding.

The values of the two resistors, R_{S1} and R_{S2} , can be calculated from the following expressions:

$$R_{S1} = \frac{R_{EO}}{2} \dots \dots \dots (5)$$

$$R_{S2} = \frac{R_{EO}}{2} - R_0 \dots \dots \dots (6)$$

where R_{EO} is the required line-to-line output resistance of the Signal Generator

R_0 is the source resistance of the Signal Generator (50 ohms).

The 50-ohm to 300-ohm UNBALANCED TO BALANCED TRANSFORMER type TM 4916 operates on the principle described above, and is fitted with a type N socket at its input end and solder spills at its output end.

When feeding balanced loads by the method described above, it is advisable, if the insertion loss can be tolerated, to also include the 20-dB PAD. The effective source e.m.f. is, of course, then reduced by a factor of 20 dB.

2.5.1. (Continued)

The D.C. ISOLATING UNIT Type TM 4917. This unit contains a 300-volt working 0.001- μ F capacitor connected in series with the output line so that the Signal Generator may be connected to a point of high d.c. potential on the equipment under test. The ISOLATING UNIT is fitted with a type N socket at its input end and two crocodile clips at its output end.

3.

MAINTENANCE

3.1. REMOVAL OF CASE

To remove the instrument from its case, first lay it face downwards on a bench, and remove the four metal domes which serve as feet; each of these domes is held at its centre by a counter-sunk screw. Next, remove the four similar domes from the back of the case. The case can now be separated from the main body of the instrument, leaving the trim attached to the front panel bezel. The mains lead passes through to the inside of the case via a hole in the left-hand case-handle recess; feed the cable through this hole as the case is lifted upwards.

3.2. REPLACEMENT OF VALVES AND CRYSTALS

After the removal of the case from the instrument, all valves are accessible with the exception of V6, the r.f. oscillator, and V2, the f.m. amplifier. Those two valves, together with the output-monitor crystal, MR2, are mounted in the screened r.f. unit.

To obtain access to the interior of the r.f. unit, remove the screening cover after extracting the 30 chooso-head fixing screws.

To remove the r.f. oscillator valve (V6), slacken, but do not remove, the two screws securing the corrugated spring-contact bands round the grid and anode connecting rings; withdraw the valve towards the bottom of the instrument. To replace V6, push the cathode/heater cylinder into its semi-floating socket until the anode and grid connecting rings engage in the spring-contact bands; lightly tighten the screws in the contact bands to secure the valve in position.

The crystal-diode, MR2, is held in a spring clip adjacent to the head of the attenuator tube; it is advisable to use a small pair of tweezers when removing it. If a new crystal is fitted, the calibration accuracy of the monitoring circuits should be checked by the following method:-

3.2. (Continued)

- (1) Monitor the output level of the Signal Generator either directly by means of an accurate sensitive valve voltmeter or by comparison with a standardized signal generator using a receiver as an indicator.
- (2) Set the ATTENUATOR to 50 mV, and adjust the SET CARRIER control to produce a source e.n.f. of 50 mV as indicated by the external monitoring equipment.
- (3) Adjust the preset control RV8, to bring the pointer of the CARRIER LEVEL meter exactly to the SET CARRIER mark.
- (4) Set up the Signal Generator for amplitude modulation, and check the modulation depth using a suitable frequency changer in conjunction with a cathode-ray oscilloscope (e.g., a receiver with the c.r.o. connected to the i.f. amplifier output). The modulation depth is given by the formula:

$$M(\%) = \frac{D_{\max} - D_{\min}}{D_{\max} + D_{\min}} \times 100$$

where $D_{\max}$ is the peak-to-peak dimension of the modulation envelope.

$D_{\min}$ is the trough-to-trough dimension of the envelope.

- (5) By means of the preset control, RV7, adjust the sensitivity of the modulation monitoring circuit until the meter indication is correct at full-scale on the 0-20 range and at 40% modulation on the 0-100 range. The indication should be accurate to within 2% modulation on the 0 to 20 range and within 5% modulation on the 0 to 100 range.

The modulation-monitor accuracy should also be checked, as detailed in (4) and (5) above, if the modulation monitoring valve, V9, is replaced.

3.3. MAINS INPUT ARRANGEMENTS

The TF 1066/1 can be operated from 40- to 60-c/s power supplies in the voltage ranges 100 to 150 and 180 to 250 volts; it can also be operated from 500-c/s supplies.

Sections 3.3.1, 3.3.2 and 3.3.3, which follow, deal only with the arrangements and adjustments necessary to accommodate different supply voltages.

The question of adjustment to suit supply frequencies of 40 to 60 c/s, or 500 c/s, is dealt with separately in Section 3.3.4.

Section 3.3.5. relates to fuses - their type and location.

3.3.1. Mains Transformer And Tapping Panel

The instrument is fitted with a mains transformer which has a double-wound primary, the two tapped sections of which can be connected in series for 180- to 250-volt operation, or in series-parallel for 100- to 150-volt operation.

The mains input to the transformer is carried on two fly-leads which are connected by screws to a 6-point tapping panel mounted separately at the side of the transformer. Attached to the tapping panel is a pierced reference plate which is reversible and marked with a selection of voltages. On one side of the reference plate, the voltages are applicable to the 100- to 150-volt range; on the other side, to the 180- to 250-volt range. The two main sections of the double-wound primary are connected together by a link or links; the links are used to join the appropriate solder-tag terminals which are mounted directly on the transformer coil. To change from one major voltage range to the other, the linking between the transformer tags is changed; to change by a small, say 10-volt, increment within one of the major ranges, the position of the screw-secured fly-leads on the tapping panel is changed.

In order to examine fully the transformer connections, the instrument must be removed from its case as described in Section 3.1. of this manual. If it is only required to view, or alter, the position of the fly-leads on the tapping panel, the instrument case need not be removed; the tapping panel is accessible after removal of the cover plate in the right-hand case-handle recess.

3.3.2. For Supply Voltages Between 180 And 250 Volts, the connection and arrangement of the transformer and tapping panel must be as follows:-

- (1) The solder-tag terminals "TAP A" and "TAP B" on the transformer must be linked together.
- (2) Other than (1) above, there must be no other cross linking between the solder-tag terminals on the transformer.
- (3) The pierced and reversible reference plate covering the tapping panel must have its side bearing the 180- to 250-volt markings visible. (The reference plate can be reversed after removing the screw-secured fly-leads and then extracting the single screw from between the "0" and "+10" tapping points).
- (4) The lead soldered to the rear of the "180" point on the tapping panel must go to the "180" solder-tag terminal on the transformer.

With the above instructions exactly complied with, the instrument can be adjusted from the tapping panel for operation from any supply voltage between 180 and 250; make the adjustment by positioning the fly-leads on the tapping panel to give a combination suitable to the particular local supply.

Example (1) For use on 180-volt supply mains, one fly-lead should be secured to the "180" position, and the other fly-lead to the "0" position.

Example (2) For use on 250-volt supply mains, one fly-lead should be secured to the "240" position and the other fly-lead to the "+10" position.

3.3.3. For Supply Voltages Between 100 And 150 Volts, the connection and arrangement of the transformer and tapping panel must be as follows:-

- (1) The solder-tag terminals "TAP A" and "100 V
200 V" on the transformer must be linked together.
- (2) The solder-tag terminals "TAP B" and "0 V" on the transformer must be linked together.

3.3.3. (Continued)

- (3) Other than (1) and (2) immediately above, there must be no other cross linking between the solder-tag terminals on the transformer.
- (4) The pierced and reversible reference plate covering the tapping panel must have its side bearing the 100- to 150-volt markings visible. (The reference plate can be reversed after removing the screw-secured fly-leads and then extracting the single screw from between the "0" and "+10" tapping points.)
- (5) The lead soldered to the rear of the "105" point on the tapping panel must go to the "105" solder-tag terminal on the transformer.

With the above instructions exactly complied with, the instrument can be adjusted from the tapping panel for operation from any supply voltage between 100 and 150; make the adjustment by positioning the fly-leads on the tapping panel to give a combination suitable to the particular local supply.

Example (1) For use on 100-volt supply mains, one fly-lead should be secured to the "100" position and the other fly-lead to the "0" position.

Example (2) For use on 115-volt supply mains, one fly-lead should be secured to the "105" position and the other fly-lead to the "+10" position.

3.3.4. Adjustment To Suit Different Mains Frequencies

The voltage-doubler circuit which provides the negative bias supply for the reactor stage, receives its a.c. input from one half of the centre-tapped h.t. winding on the mains transformer. This a.c. input is reduced to the correct level by means of a series capacitance, which, when the instrument is being fed from 40- to 60-c/s mains supplies, comprises C47 (0.05 μ F) and C24 (0.5 μ F) in parallel. For 500-c/s operation, this capacitance must be made smaller; to do this it is only necessary to cut or remove the soldered link between pin 5 (blank) and pin 6 (anode) on the holder of V1, the main rectifier valve. This action effectively removes C24 from circuit.

3.3.4. (Continued)

To sum up:-

For 40 - 60 c/s supplies, C47 and C24 should both be in circuit.

For 500 c/s supplies, only C47 should be in circuit.

3.3.5. Fuses

The power unit in the TF 1066/1 is protected by three fuses: there are two 2-amp fuses in the mains input circuit and one 250-mA fuse in series with the centre tap of the h.t. secondary winding on the mains transformer.

These fuses can be inspected and, if necessary, replaced without removing the instrument from its case; they are of the glass-cartridge type and their screw-in holders are mounted in the right-hand case-handle recess.

3.4. POWER UNIT VOLTAGES

Measured with a Model 40 Avometer set to its highest convenient range, and with the mains transformerappings adjusted to suit the particular local supply, the h.t. and l.t. voltages should be of the following order:

Mains Transformer, h.t. secondary:	350-0-350 volts a.c.
l.t. 1:	6.3 volts a.c.
l.t. 2:	6.3 volts a.c.
l.t. 3:	5.0 volts a.c.
l.t. 4:	18.0 volts a.c.
H.T. rectified (across C2):	420 volts d.c.
" " (across C3):	410 volts d.c.
H.T. stabilized (V3, pin 8):	280 volts d.c.

NOTE: The H.T. stabilized voltage is controlled by preset potentiometer RV4. Adjustment to RV4 should, however, be made only to correct the indication of incremental frequency. For this purpose set the INC FREQ switch to VAR, the monitor-selector switch to INC FREQ 0-20, and the modulation-selection switch to EXT F.M. Short-circuit the EXT MOD F.M. terminals and adjust RV4 for an indication of 0 on the red scale of the MODULATION AND INCREMENTAL FREQUENCY meter.

AMENDMENT SHEET No. AM1Operating Instructions

for

FM and AM Signal GeneratorType TF 1066/1Changes to Circuit Diagram TC 24602/1Heater-voltage regulator for r.f. valves.

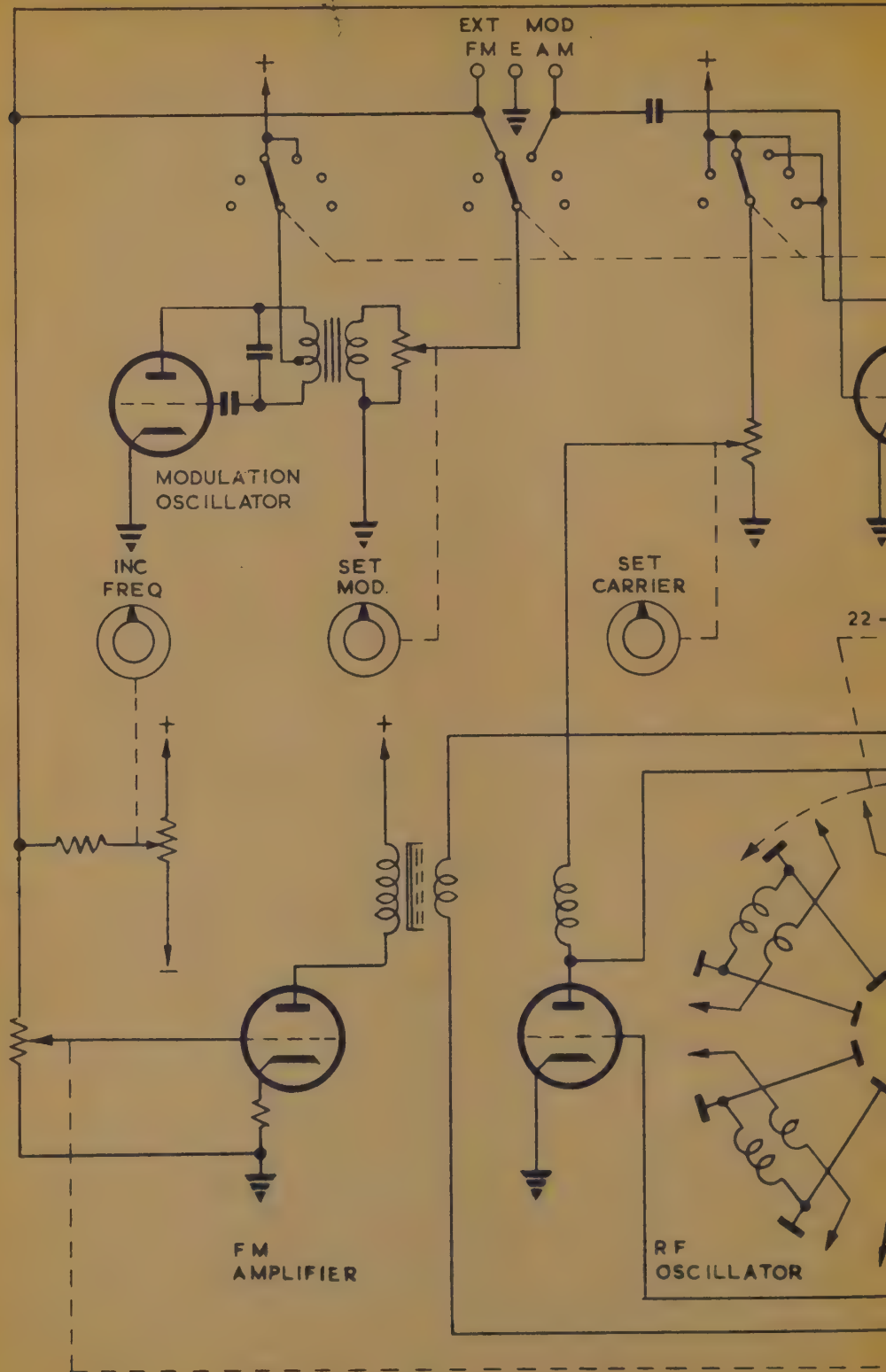
The circuit diagram shows the heater-voltage regulator as designed for use with the original version of DET 22 oscillator valves. These valves have a rated heater-current of 0.4 amps. The valve manufacturers are now supplying a later version of the DET 22 which has a rated heater-current of 0.5 amps. When the later-version valves are used the circuit is modified as follows:-

- (a) Resistor R87 is deleted;
- (b) A resistor is connected in parallel with barretters V11 and V12. The value of this resistor (approx 12 ohms) is chosen to give a voltage of 6.3 V a.c. at the heater connections of V6.

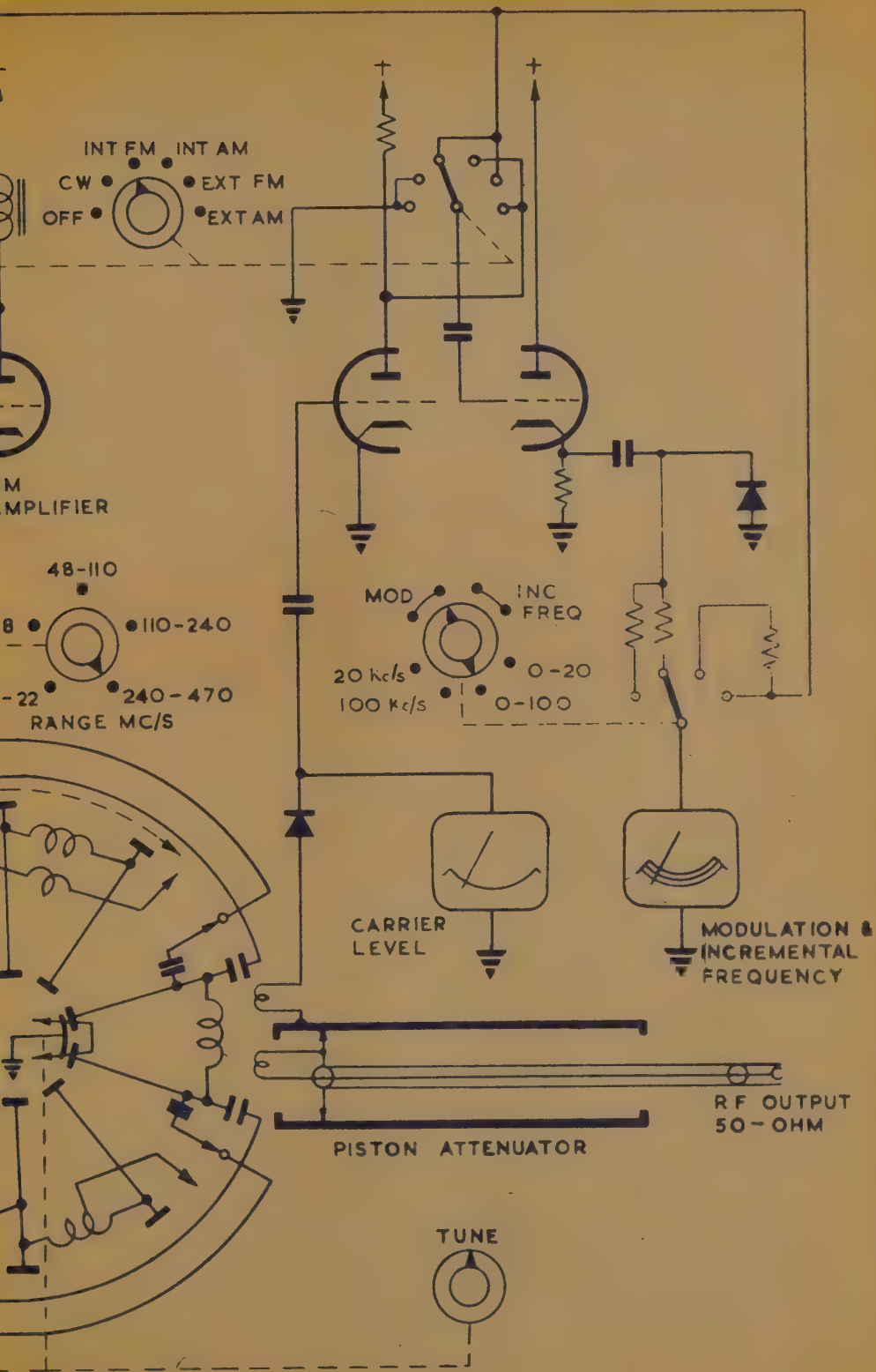
The original version (0.4-amp heater) has a black paper label. The later version (0.5-amp heater) has the valve type number printed directly on the glass envelope.

FUNCTIONAL DIAGRAM
OF
FM & AM SIGNAL GENERATOR
TYPE TF 1066 & TF1066/1

MARCONI INSTRUMENTS LIMITED							
DRN	J.F.G	DATE	22-3-55	TRCD	H.J.F.	CHKD	~~///~~
STOCK LIST		TF 1066-1		DRG N°		TBB 24743	



FUNCTIONAL DIAGRAM OF FM & AM



SIGNAL GENERATOR TYPE TF1066 & TF1066/1

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16 AUG 1957

OUTPUT ARRANGEMENT DIAGRAMS

MARCONI INSTRUMENTS LIMITED

DRN.	J. F. G.	DATE	3.10.55	TRCD	H. J. F.	CHKD	<i>[Signature]</i>
STOCK LIST		TF1066-/1		DRG No		TBB25403	

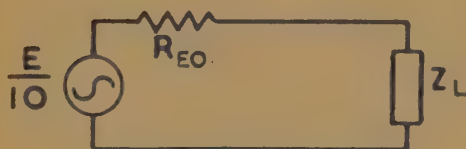


E IS THE E.M.F. INDICATED ON THE ATTENUATOR DIAL
 R_o IS THE OUTPUT RESISTANCE OF THE TF 1066-1/1 = 50 OHMS
 Z_L IS THE LOAD IMPEDANCE
 V_L IS THE VOLTAGE APPEARING ACROSS THE LOAD

FIGURE 1 OUTPUT CONDITIONS FOR DIRECT COUPLING



OUTPUT CIRCUIT WITH 20-dB PAD IN USE. THIS IS EQUIVALENT TO:-

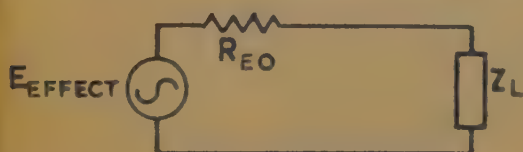


WHERE $R_{EO} = R_o$

FIGURE 2 OUTPUT CONDITIONS FOR COUPLING VIA THE 20-dB PAD



OUTPUT CIRCUIT FOR SOURCE RESISTANCE < 50 OHMS
 THIS IS EQUIVALENT TO:-



WHERE $E_{EFFECT} = E \frac{R_p}{R_p + R_o}$
 $R_{EO} = \frac{R_p R_o}{R_p + R_o}$

FIGURE 3 OUTPUT CONDITIONS USING PARALLEL RESISTOR



OUTPUT CIRCUIT FOR SOURCE RESISTANCE > 50 OHMS
THIS IS EQUIVALENT TO:-

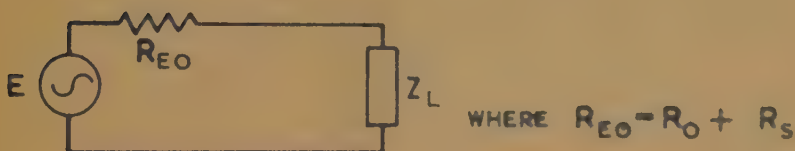


FIGURE 4 OUTPUT CONDITIONS USING SERIES RESISTOR



OUTPUT CIRCUIT FOR BALANCED LINE-TO-LINE SOURCE
RESISTANCE > 100 OHMS. WHEN FEEDING INTO BALANCED
WINDING THIS IS EQUIVALENT TO:-

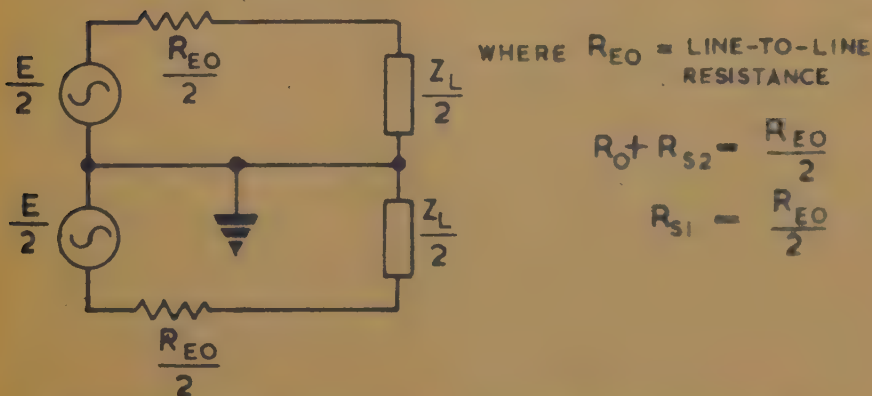
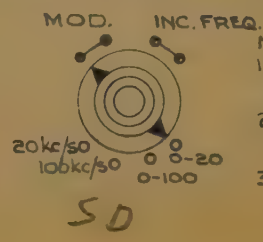
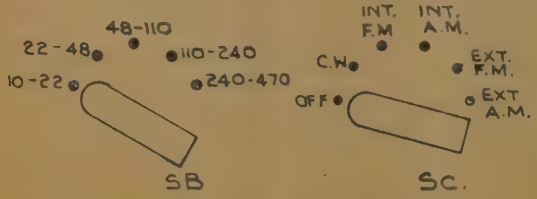
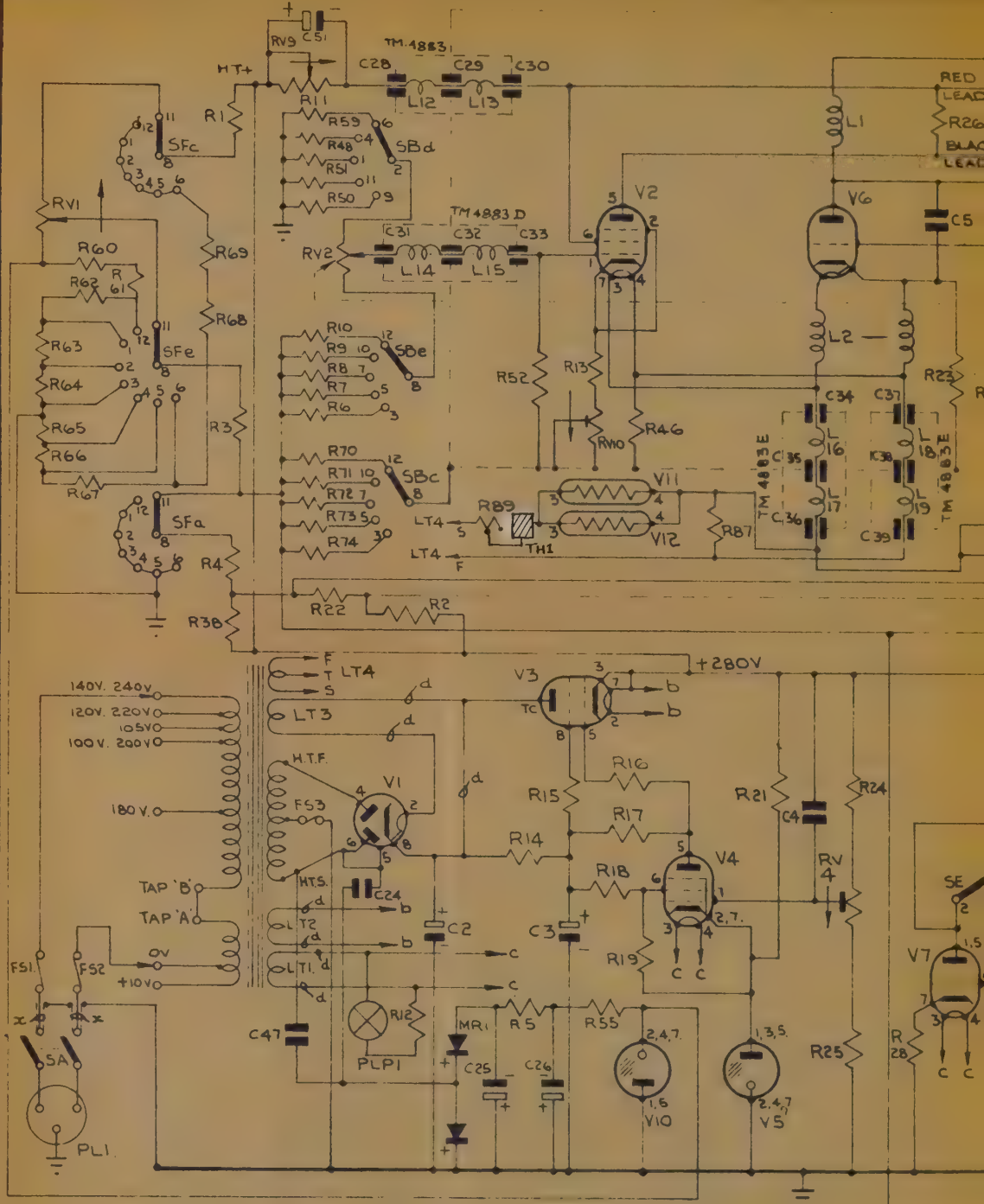
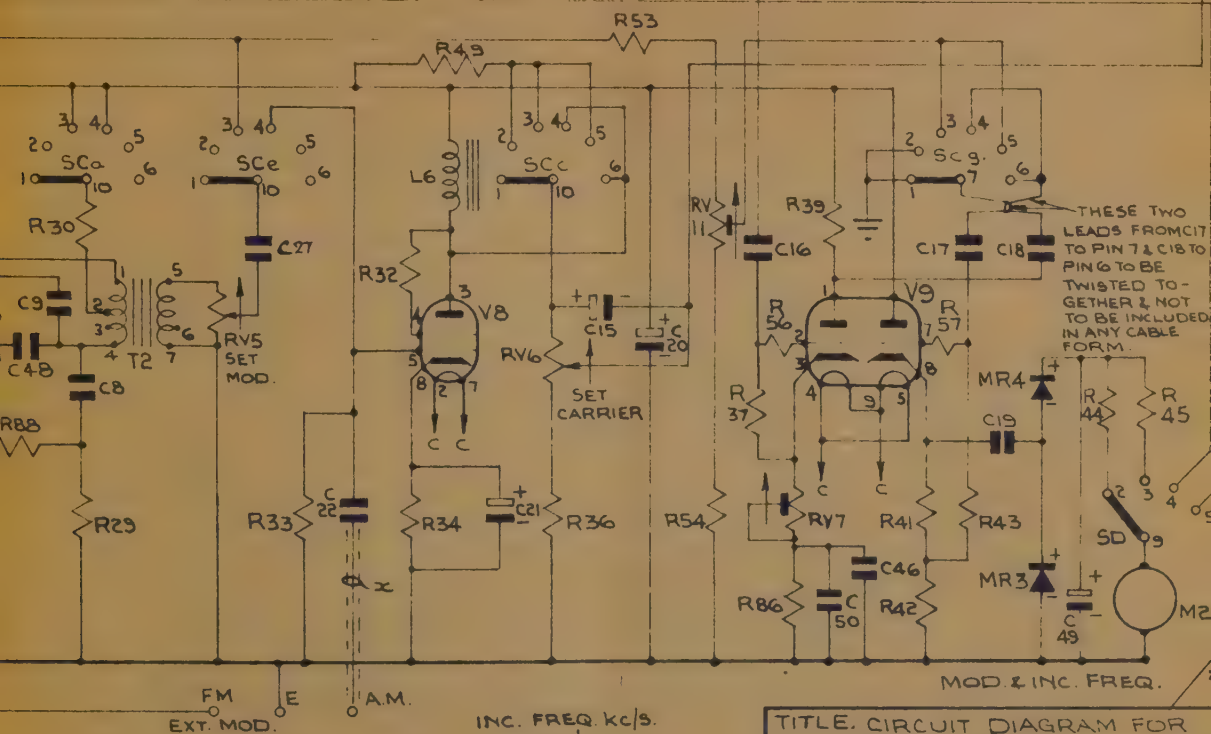
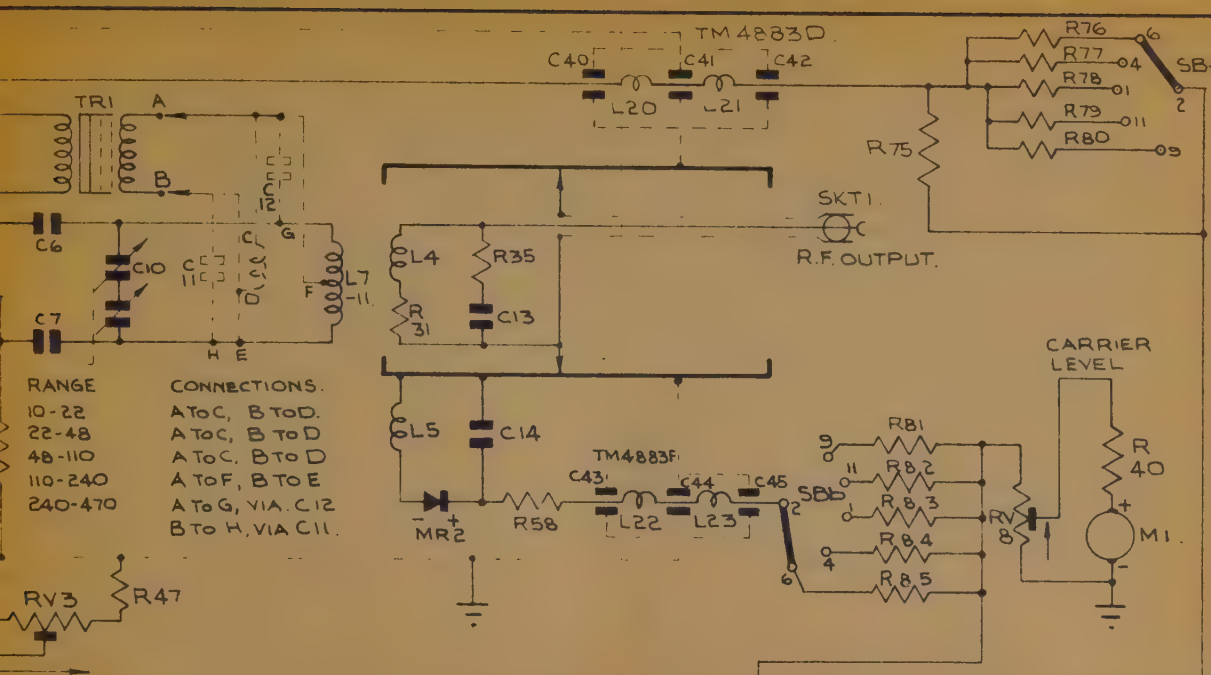


FIGURE 5 OUTPUT CONDITIONS FOR COUPLING TO
BALANCED LOAD



- NOTES.
1. SEE SHT. 2 FOR C. LIST.
 2. WIRES MARKED BE IN TC 2070
 3. WIRES MARKED TO BE IN TYPE I CABLE TO DEF.

NOTE:- FOR 500 C/B OPERATION REMOVE LINK BETWEEN PINS 526 ON V1.



COMPONENT

THUS δ d TO

0/5

THUS δ x

SCREENED.

D.

1kc/s. MOD 0 0 3

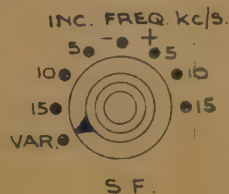
0 0 2

5kc/s. FREQ. 0 0 1

1-2 = 5 kc/s.

2-3 = 1 kc/s.

S.E.



TITLE. CIRCUIT DIAGRAM FOR	
SIG. GEN. TYPE TF 1066/1	
DRN. B.R.CULLUM	ASSY. TE 24600/
DATE. 13-3-56.	WIRING.
CHK. A.H.	S LIST. TF. 1066/1
APP. E.G.	DRAWING No.
TRACED. W.L.D.S	TC24602/1
	SHT. 1 OF 2 SHEETS.

MARCONI INSTRUMENTS LTD

REF.	RESISTORS	S.L. REF	R51	3.3k Ω S.I.C.	1/4W.	10/TM5071/1		VAR
R1	22k Ω $\pm$ 5%	1W. 13/TF1066/1	R52	1M Ω $\pm$ 10%	1/4W.	19/TM5067/1	RV1	50k Ω $\pm$ 5%
R2	5.6M Ω $\pm$ 2%	3/4W. 14/TF1066/1	R53	56k Ω $\pm$ 5%	1/4W.	35/TM5066/1	RV2	5k Ω $\pm$ 5% INVERTED
R3	10k Ω $\pm$ 5%	1/2W. 4/TM5279	R54	15k Ω $\pm$ 5%	1/4W.	36/TM5066/1	RV3	500 Ω $\pm$ 5%
R4	120k Ω $\pm$ 2%	1/4W. 16/TF1066/1	R55	15k Ω $\pm$ 5%	1W	44/TM5066/1	RV4	50k Ω $\pm$ 5%
R5	4.7k Ω $\pm$ 5%	3W. 30/TM5066/1	R56	4.7k Ω $\pm$ 10%	1/4W.	14/TM5066/1	RV5	40k Ω $\pm$ 5% S.M.I.-E.C.
R6	1-4.7k Ω $\pm$ 10% S.I.C.	1/4W. 9/TM5071/2	R57	4.7k Ω $\pm$ 10%	1/4W.	14/TM5066/1	RV6	22k Ω $\pm$ 5%
R7	1-4.7k Ω $\pm$ 10% S.I.C.	1/4W. 9/TM5071/2	R58	100 Ω $\pm$ 10%	1/4W.	20/TM5067/1	RV7	10k Ω $\pm$ 5%
R8	1-4.7k Ω $\pm$ 10% S.I.C.	1/4W. 9/TM5071/2	R59	4.7k Ω $\pm$ 10% S.I.C.	1/4W.	11/TM5071/1	RV8	5k Ω $\pm$ 5%
R9	1-4.7k Ω $\pm$ 10% S.I.C.	1/4W. 9/TM5071/2	R60	6.8k Ω $\pm$ 10% S.I.C.	1/4W.	25/TM5066/1	RV9	15k Ω $\pm$ 5%
R10	1-4.7k Ω $\pm$ 10% S.I.C.	1/4W. 9/TM5071/2	R61	15k Ω $\pm$ 5%	1/2W.	6/TM5279	RV10	3k Ω $\pm$ 5%
R11	10k Ω $\pm$ 10% S.I.C.	1/4W. 8/TM5071/1	R62	1.2k Ω $\pm$ 2%	1/4W.	7/TM5279	RV11	15k Ω $\pm$ 5%
R12	10 Ω $\pm$ 10%	1/2W. 11/TM5066/1	R63	1.05k Ω $\pm$ 2%	1/4W.	8/TM5279	C1	
R13	3.3k Ω $\pm$ 10%	1/2W. 21/TM5067/1	R64	900 Ω $\pm$ 2%	1/4W.	9/TM5279	C2	8 μ F $\pm$ 50%
R14	1k Ω $\pm$ 10%	1/4W. 12/TM5066/1	R65	630 Ω $\pm$ 2%	1/4W.	10/TM5279	C3	32 μ F $\pm$ 5%
R15	100 Ω $\pm$ 10%	1/4W. 13/TM5066/1	R66	650 Ω $\pm$ 2%	1/4W.	11/TM5279	C4	25 μ F $\pm$ 5%
R16	4.7k Ω $\pm$ 10%	1/4W. 14/TM5066/1	R67	670 Ω $\pm$ 2%	1/4W.	12/TM5279	C5	10 μ F $\pm$ 5%
R17	680k Ω $\pm$ 10%	1/4W. 15/TM5066/1	R68	15k Ω $\pm$ 5%	1/2W.	6/TM5279	C6	27PF $\pm$ 5%
R18	330k Ω $\pm$ 10%	1/4W. 16/TM5066/1	R69	68k Ω $\pm$ 10% S.I.C.	1/4W.	25/TM5066/1	C7	27PF $\pm$ 5%
R19	47k Ω $\pm$ 10%	1/4W. 17/TM5066/1	R70	10k Ω $\pm$ 10% S.I.C.	1/4W.	5/TM5071/2	C8	0.01 μ F $\pm$ 5%
R20			R71	33k Ω $\pm$ 10% S.I.C.	1/4W.	6/TM5071/2	C9	0.005 μ F $\pm$ 5%
R21	100k Ω $\pm$ 10%	1/2W. 18/TM5066/1	R72	18k Ω $\pm$ 10% S.I.C.	1/4W.	5/TM5071/2	C10	50PF $\pm$ 5%
R22	480k Ω $\pm$ 2%	1/4W. 20/TF1066/1	R73	56k Ω $\pm$ 10% S.I.C.	1/4W.	7/TM5071/2	C11	1.5PF $\pm$ 5%
R23	330 Ω $\pm$ 10%	1/4W. 16/TM5067/1	R74	S.I.C.		8/TM5071/2	C12	1PF $\pm$ 5%
R24	100k Ω $\pm$ 10%	1/4W. 19/TM5066/1	R75	15k Ω $\pm$ 10% 10W.		12/TM5071/1	C13	47PF $\pm$ 5%
R25	33k Ω $\pm$ 10%	1/4W. 101/TM5066/1	R76	S.I.C.		13/TM5071/1	C14	200PF $\pm$ 5%
R26	330k Ω S.I.C.	1/2W. 14/TM5067/1	R77	S.I.C.		14/TM5071/1	C15	8 μ F $\pm$ 50%
R27	10k Ω $\pm$ 10%	1/4W. 15/TM5067/1	R78	8.2k Ω $\pm$ 10% S.I.C.	1W.	15/TM5071/1	C16	25 μ F $\pm$ 5%
R28	2.2k Ω $\pm$ 10%	1/4W. 22/TM5066/1	R79	18k Ω $\pm$ 10% S.I.C.	1W.	16/TM5071/1	C17	0.05 μ F $\pm$ 5%
R29	220k Ω $\pm$ 10%	1/4W. 21/TM5066/1	R80	S.I.C.		17/TM5071/1	C18	0.05 μ F $\pm$ 5%
R30	2.2k Ω $\pm$ 10%	1/4W. 22/TM5066/1	R81	390 Ω $\pm$ 10% S.I.C.	1/4W.	18/TM5071/1	C19	6 μ F $\pm$ 5%
R31	47 Ω $\pm$ 5%	1/4W. 19/TM4819/1	R82	S.I.C.		19/TM5071/1	C20	8 μ F $\pm$ 5%
R32	100 Ω $\pm$ 10%	1/4W. 13/TM5066/1	R83	1.8k Ω $\pm$ 10% S.I.C.	1/4W.	20/TM5071/1	C21	25 μ F $\pm$ 10%
R33	1M Ω $\pm$ 10%	1/4W. 23/TM5066/1	R84	1.2k Ω $\pm$ 10% S.I.C.	1/4W.	21/TM5071/1	C22	1 μ F $\pm$ 20%
R34	1k Ω $\pm$ 10%	1/2W. 24/TM5066/1	R85	680 Ω $\pm$ 10% S.I.C.	1/4W.	22/TM5071/1	C23	
R35	47 Ω $\pm$ 5%	1/4W. 19/TM4819/1	R86	2.2k Ω $\pm$ 10%	1/4W.	22/TM5066/1	C24	5 μ F $\pm$ 5%
R36	15k Ω $\pm$ 10%	1W. 22/TF1066/1	R87	240 Ω $\pm$ 5%	3/4W.	32/TM5066/1	C25	8 μ F $\pm$ 50%
R37	1M Ω $\pm$ 10%	1/4W. 23/TM5066/1	R88	47k Ω $\pm$ 10%	1/4W.	29/TM5066/1	C26	8 μ F $\pm$ 5%
R38	70M Ω $\pm$ 20%	1/8W. 21/TF1066/1	R89	15 Ω TAPPED	10W.	22/TF1066/1	C27	1 μ F $\pm$ 2%
R39	270k Ω $\pm$ 10%	1/4W. 87/TM5066/1					C28	4700PF $\pm$ 5%
R40	1.2k Ω $\pm$ 10%	1/4W. 88/TM5066/1					C29	4700PF $\pm$ 5%
R41	470 Ω $\pm$ 10%	1/4W. 27/TM5066/1					C30	4700PF $\pm$ 5%
R42	33k Ω $\pm$ 10%	1/2W. 28/TM5066/1					C31	200PF $\pm$ 5%
R43	1M Ω $\pm$ 10%	1/4W. 23/TM5066/1					C32	200PF $\pm$ 5%
R44	15k Ω S.I.C.	1/4W. 83/TM5066/1					C33	200PF $\pm$ 5%
R45	100k Ω S.I.C.	1/8W. 84/TM5066/1					C34	4700PF $\pm$ 5%
R46	10 Ω $\pm$ 10%	1/4W. 18/TM5067/1					C35	4700PF $\pm$ 5%
R47	470 Ω 10%	1/4W. 27/TM5066/1					C36	4700PF $\pm$ 5%
R48	4.7k Ω S.I.C.	1/4W. 11/TM5071/1					C37	4700PF $\pm$ 5%
R49	2.2k Ω $\pm$ 3%	3W. 3/TM5066/1					C38	4700PF $\pm$ 5%
R50	6.8k Ω S.I.C.	1/4W. 9/TM5071/1					C39	4700PF $\pm$ 5%

BLE R.		C40	200 PF	500V.	5/TM.4883 D	V8	6L6 OR XT66 (CV1947)	75/TF 1066/1
0% 1W.	10/TF 1066/1	C41	200 PF	500V.	6/TM.4883 D.	V9	12AX7 (CV492)	80/TF 1066/1
SEMI-LOG	12/TM 5067/1	C42	200 PF	500V.	6/TM.4883 D.	V10	0A2 (CV1833)	77/TF 1066/1
0% 1W.	8/TF 1066/1	C43	1000 PF	500V.	5/TM.4883 F	V11	XBI (CV2293)	78/TF 1066/1
0% 1W.	8/TM 5066/1	C44	1000 PF	500V.	6/TM.4883 F.	V12	XBI (CV2293)	78/TF 1066/1
0% LAW 1W.	11/TF 1066/1	C45	1000 PF	500V.	6/TM.4883 F.		MISCELLANEOUS	
0% 7 1/2 W.	12/TF 1066/1	C46	.005 μ F $\pm$ 20% S.I.C. 400V	33/TM.5066/1	T1	100V. 2200V MAINS TRANS. INPUT	1/TM.5066/1	
0% 1W.	9/TM 5066/1	C47	.05 μ F $\pm$ 20% 500V.	46/TM.5066/1	T2	MOD. TRANS. TUNED	2/TM.5066/1	
0% 1W.	10/TM 5066/1	C48	500 PF $\pm$ 20% S.I.C. 350V	9/TM.1296 F	TH1	THERMISTOR	D594	
0% 2W	9/TF 1066/1	C49	8 μ F + 50% - 20% 450V	34/TM 5066/1				
0% 1/2 W	11/TM 5067/1	C50	.002 μ F $\pm$ 20% 400V	47/TM 5066/1	TR1	REACTOR UNIT	3/TM.5067/1	
0% 1W	7/TM 5066/1	C51	8 μ F + 50% - 20% 450V	34/TM 5066/1				
						SA	D.P.D.T. MAINS	68/TF 1066/1
						SB	OAK SWITCH 3 SEC. 5 POSN	82/TM.5067/1
						SC	OAK SWITCH 4 SEC. 6 POSN	53/TM 5066/1
						SD	OAK SWITCH 1 SEC. 4 POSN	69/TF 1066/1
						SE	D.P.D.T. MOD	68/TF 1066/1
						SF	OAK SWITCH 3 SEC 8 POSN	6/TF 1066/1

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